

Updating and Enhancing the MA3T Vehicle Choice Model

Project ID #: VAN005

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Annual Merit Review

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Timeline

- **Start: Oct 1, 2011**
- **End: Sep 30, 2013**
- **60% complete**

Budget

- **Total funding: \$770k**
 - **DOE share: 100%**
- **FY12: \$375k**
- **FY13: \$395k**

Barriers & Targets

- **A user-friendly tool for scenario analysis of various barriers**
 - Costs of advanced powertrains
 - Behavior of manufactures and consumers
 - Infrastructure
 - Incentives, regulations and other policies

Partners

- **SRA International, Inc.**
 - Data and result processing
 - Model application and testing
- **Argonne National Laboratory**
 - Vehicle data
 - Model application
- **Iowa State University**
 - Scenario setup
 - Infrastructure research

MA3T—a scenario analysis tool for estimating market shares, social benefits and costs during LDV powertrain transitions, as resulting from technology, infrastructure, behavior, and policies

- **Market shares, public benefits, and public costs**
 - Impact measurements, including sales % by technology, CO2, petroleum use, etc.
- **Technology –how to prioritize and diversify R&D investments?**
 - Batteries, motors, engines, fuel cells, electronics, light-weight, H2 storage
- **Infrastructure—what is the optimal pace of deployment?**
 - Charging (home, workplace, public); fueling (hydrogen, diesel, natural gas)
- **Behavior—implications of our knowledge of behavior?**
 - Risk aversion, value of range, value of efficiency, payback period
- **Policies—what policies could generate large benefits at low costs?**
 - Direct purchase subsidy, tax credit, fee-bate, fuel economy regulations, etc.

Main goal of the project—a more useful, credible, and user-friendly version of MA3T

Before FY13, MA3T was fully-functional and being used for DOE analysis. But new data and user feedback call for improvements

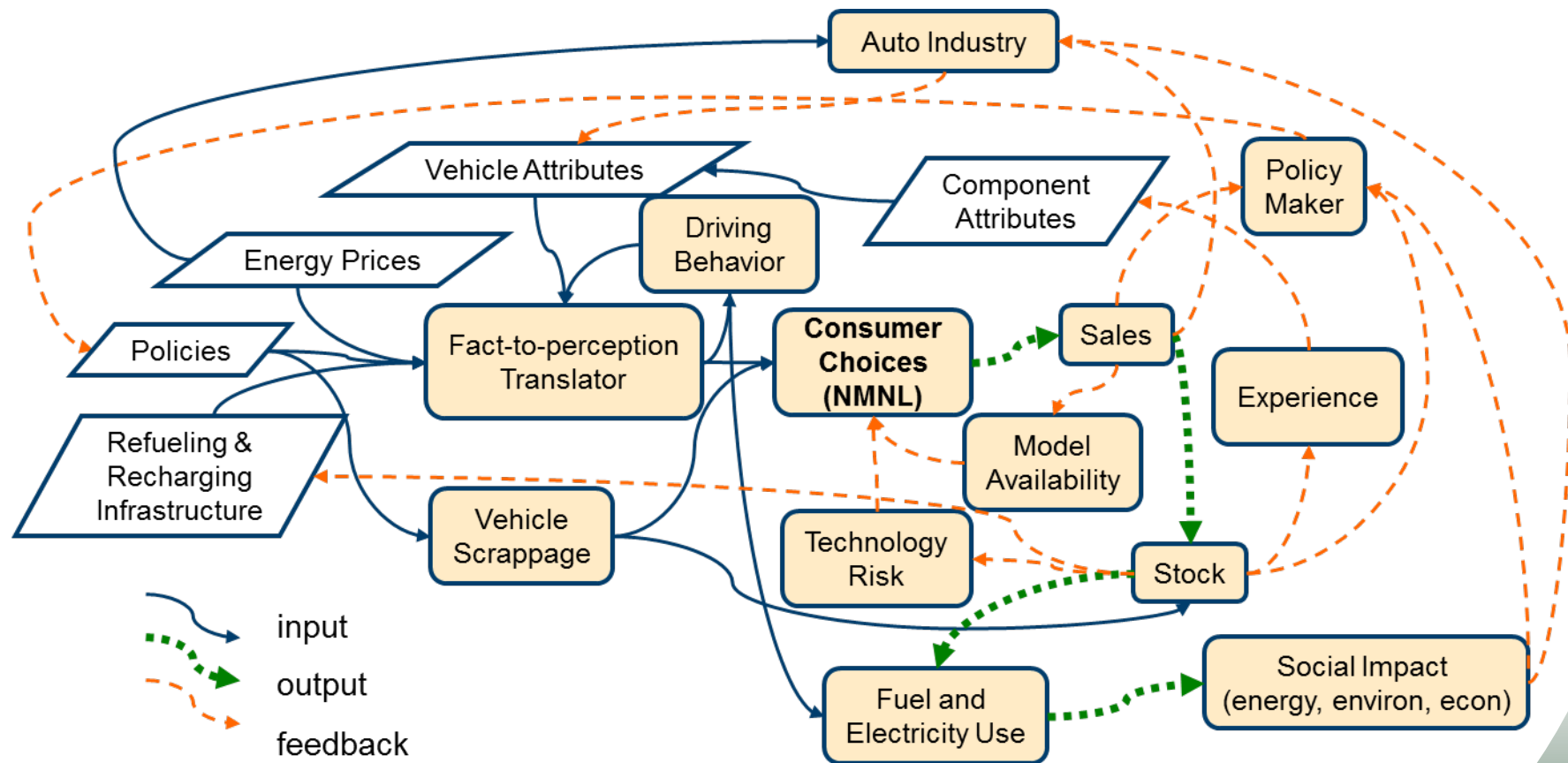
- **Status before FY13**

- NMNL integrated with comprehensive sub-models; 1458 US LDV segments; 40 vehicle choices; relevant vehicle attributes; 2005-2050
- Vehicle price, fuel economies, refueling hassle, range limitation, etc
- Infrastructure: hydrogen, natural gas, electricity, diesel; home, work, public charging
- Learning by doing, daily distance variation, station location, charging benefits, supply constraints, infrastructure utilization, policy design

- **Issues that call for improvements**

- Economy of scale and pricing for new technologies
- Buy or no-buy LDV decisions
- Computation time
- Parameter calibration
- Result validation

Around the core NMNL sub-model of consumer choice, MA3T considers many policy-relevant aspects of LDV transitions



In FY13, Six tasks to make MA3T more useful, credible and user-friendly

- **Structure upgrading**
 - Implementing new mathematical relationships or improving algorithms of existing relationships
- **Data updating**
 - Vehicle attributes, energy prices, infrastructure, etc.
- **Parameter calibrating**
 - Adjusting parameters to partially account for unknown factors
- **Result validating**
 - Comparing predicted market shares to actual
- **Application**
 - GPRA analysis, TEF study, Program Goal Study, Fueleconomy.gov PHEV Calculator
- **Publication**

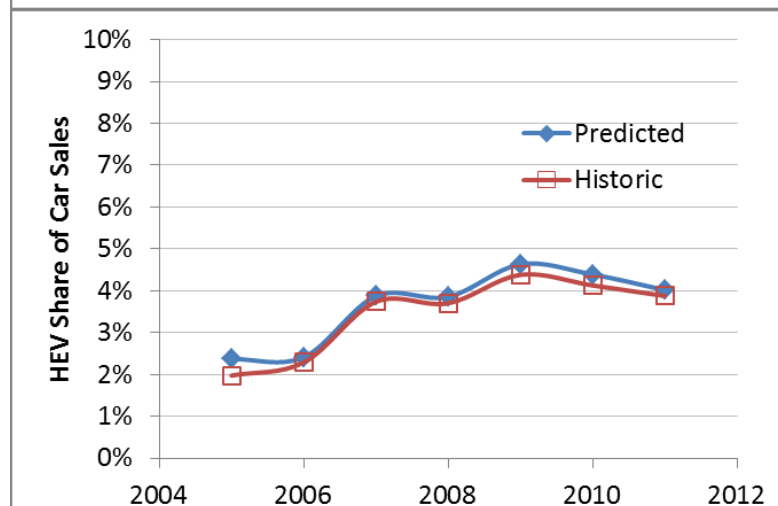
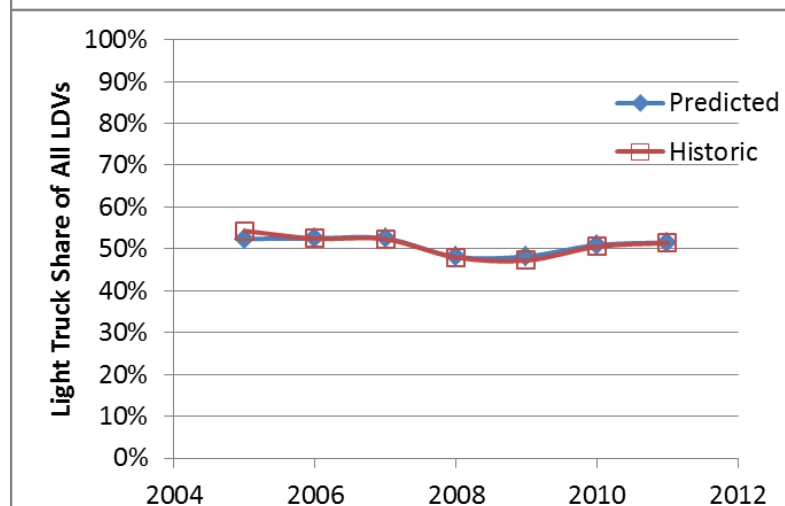
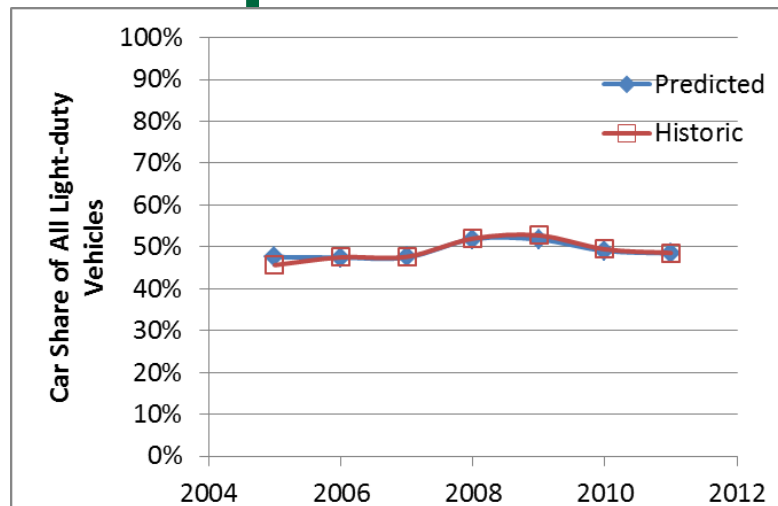
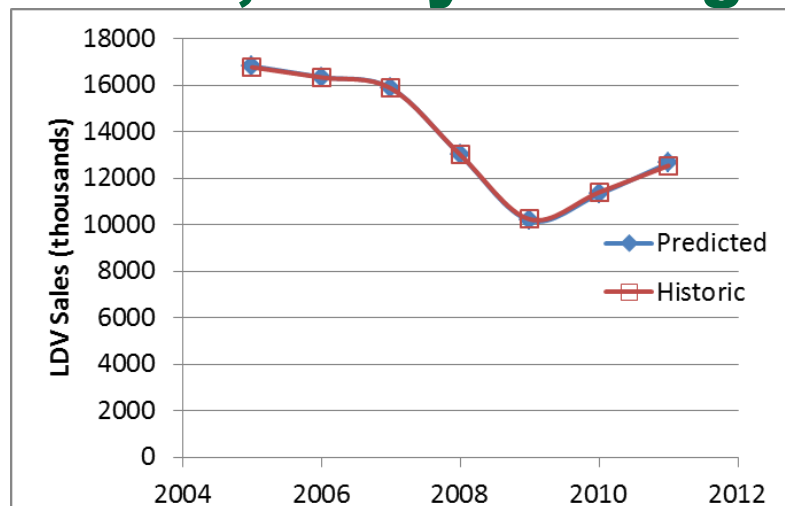
Implementing new mathematical relationships and improving algorithms of existing ones make MA3T more useful and user-friendly

- **Automatic calibration** (new math, completed)
 - Allows easy and continued “learning from history”
- **Endogenous LDV purchase** (new math, completed)
 - Relevant to rebound effect, employment and social impacts
- **Natural gas vehicle and infrastructure** (new math, completed)
- **Faster calculation of energy use** (new algorithm, completed)
 - Closed-form algorithm replaces previous enumeration method
 - Reduce computation time per run from 30 minutes to 5 minutes

For result relevancy and credibility, MA3T keeps up with new data and projections of technologies, behavior, infrastructure and policies.

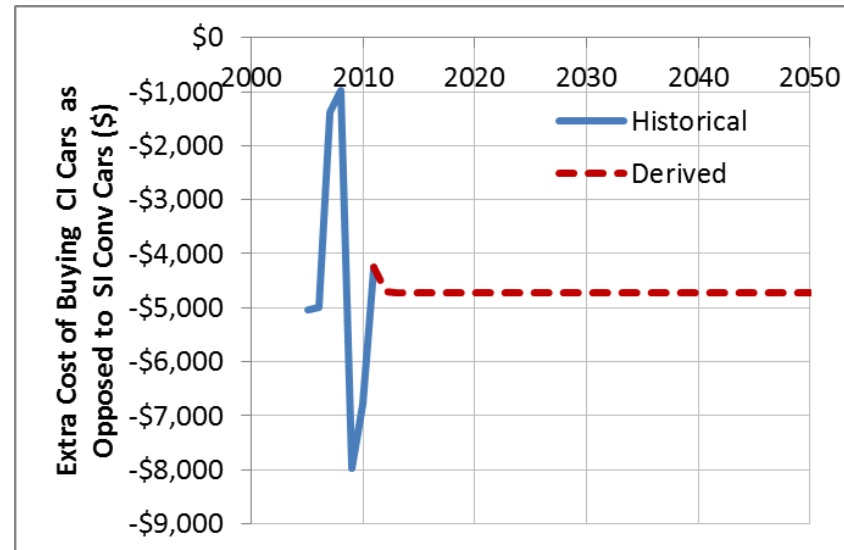
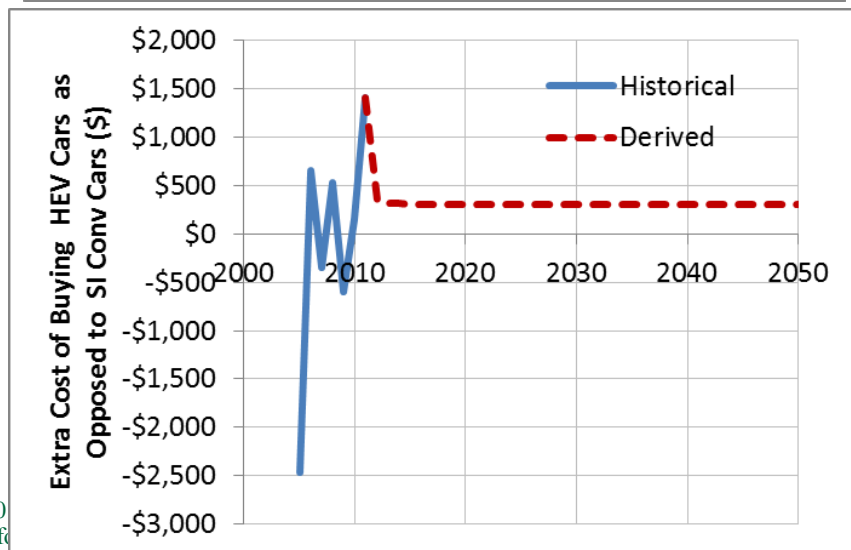
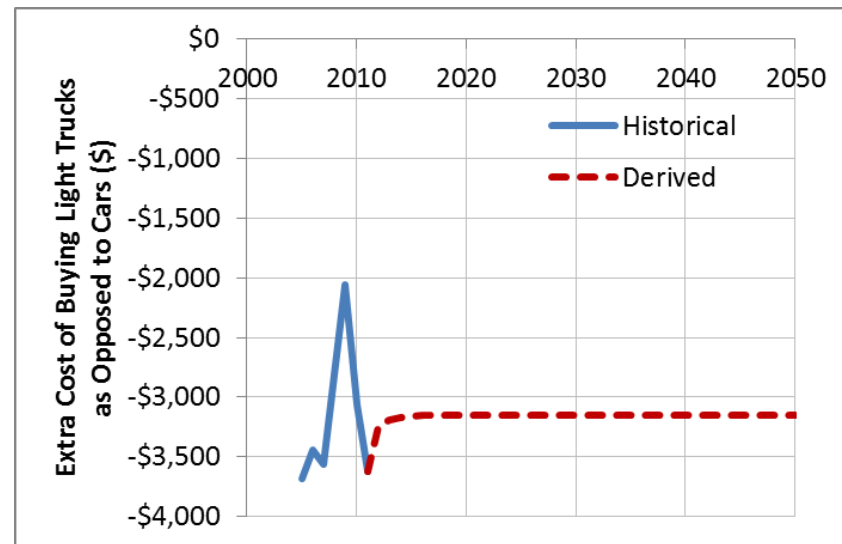
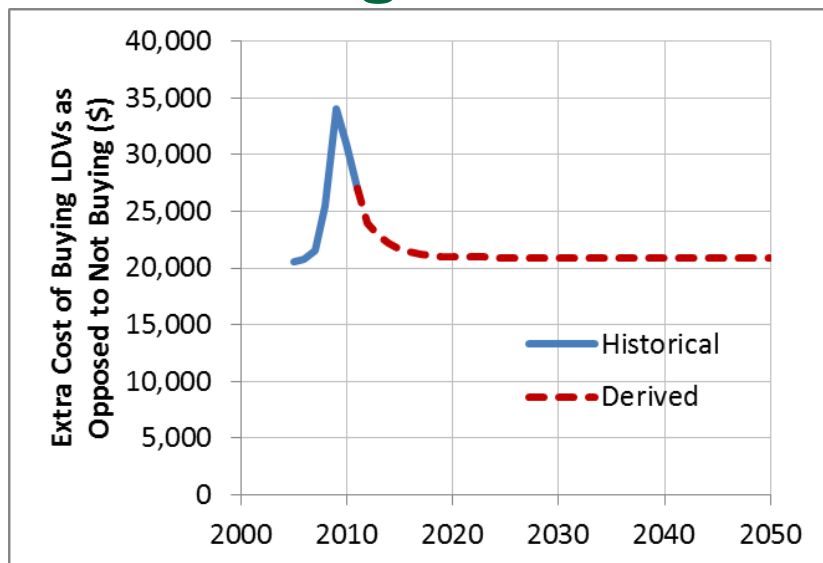
- **Vehicle data** (completed)
 - Automonie simulation results used in GPRA14 Low
- **Demographics and energy prices** (completed)
 - AEO 2012
- **Historical sales data** (completed)
 - ORNL Transportation Energy Databook, ANL PEV Sales Data, WardsAuto, Autonews.com, Hybriddashboard.com
- **Charger cost** (completed)
 - Morrow 2008; Volt and Leaf[®] charger pricing information

Calibrating NMNL constants to historical data allows capturing the aggregate effect of implicit factors, likely making model outputs more credible

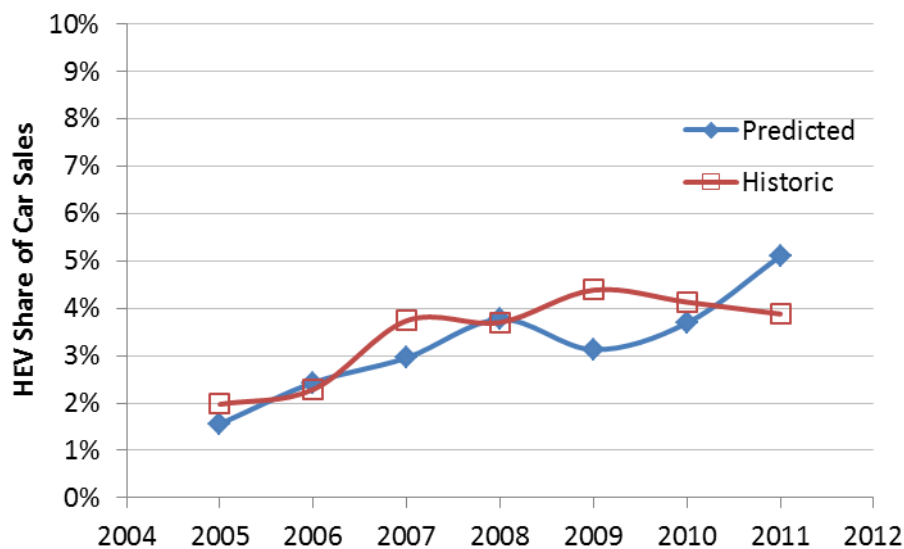
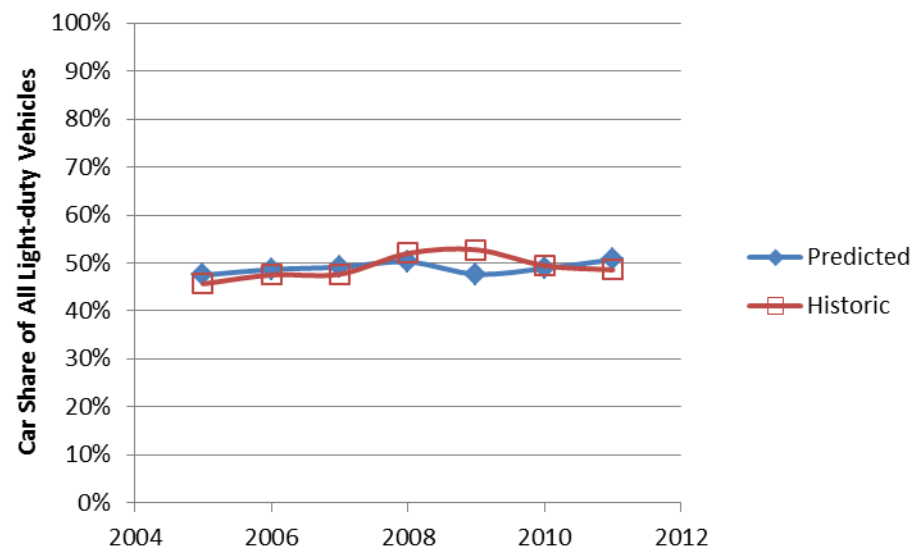
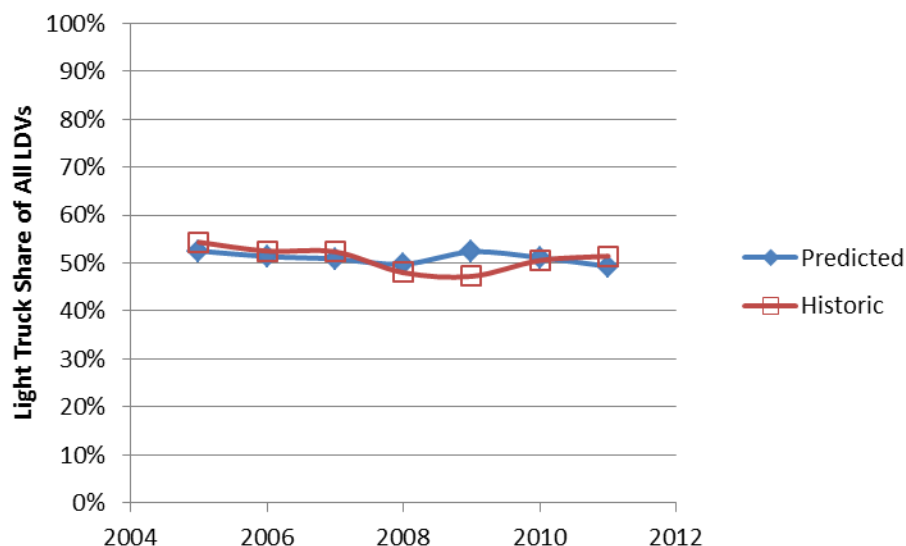


Above results show calibration quality, not prediction accuracy

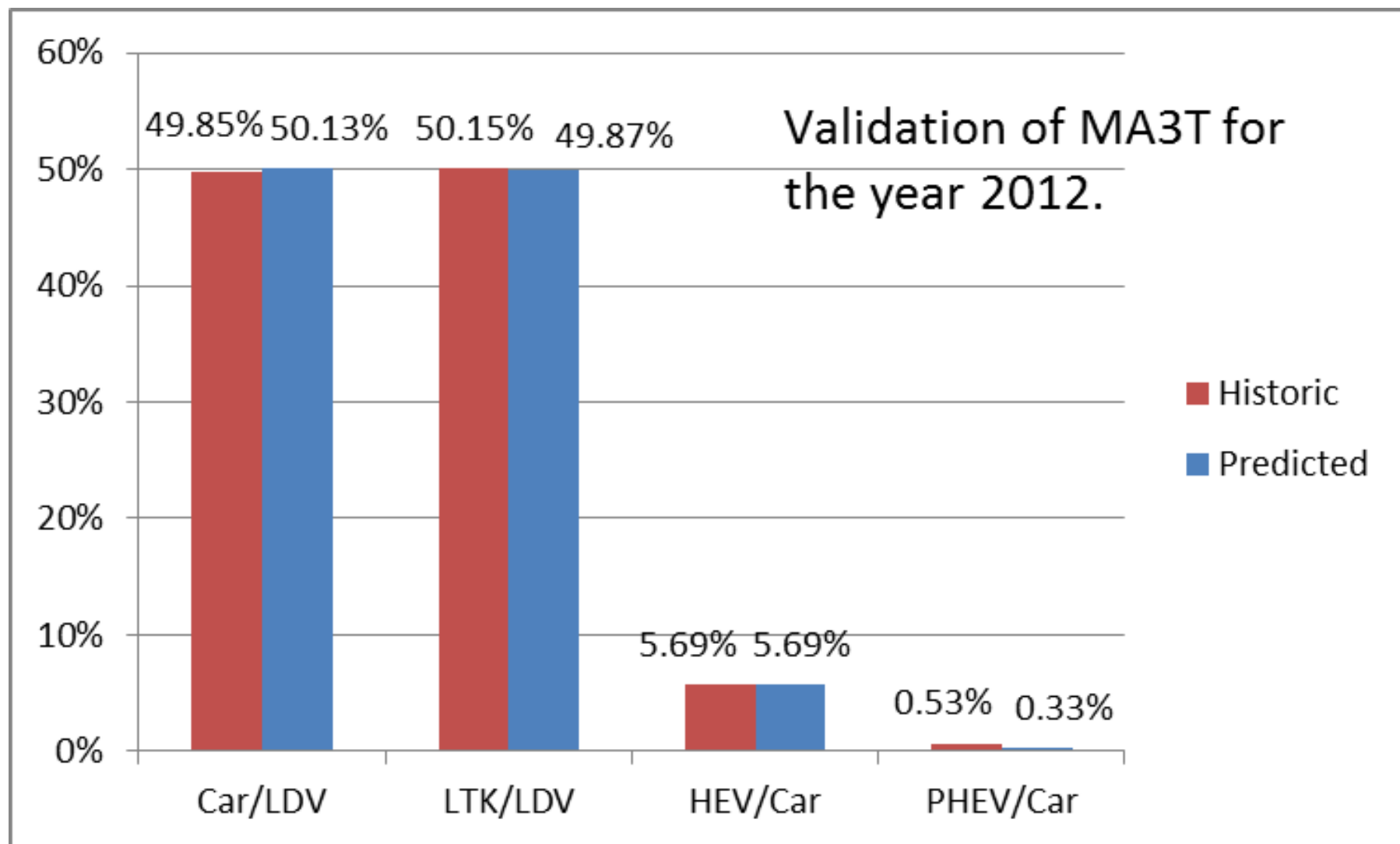
Calibrated constants reveal useful information, e.g. consumers prefer trucks over cars for unknown reasons or ignored factors



Validation results show MA3T can back-cast historical market shares with acceptable accuracy.



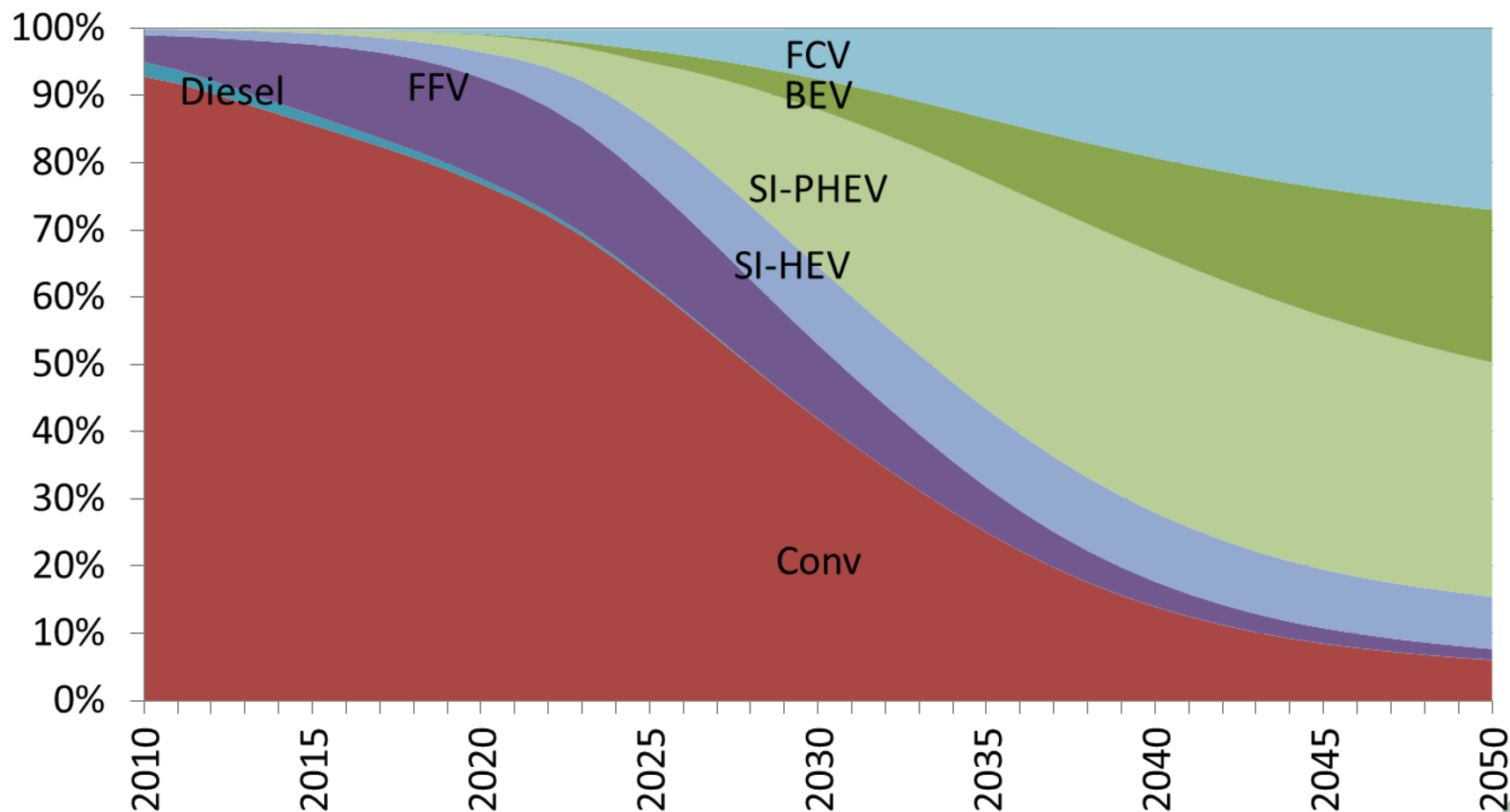
Validation results show reasonable accuracy of MA3T in predicting near-term market shares.



MA3T or its methods have been used in several important studies supported by DOE.

- **ANL VTP GPRA report for FY 2012**
- **Transportation Energy Future (TEF) study**
- **DOE Program Goals (PG) analysis**
- **Consumer Preference Sensitivity (CPS) analysis**
- **Fueleconomy.gov PHEV Calculator**
- **Range Optimization study**

MA3T was used to project market shares of LDV technologies in the TEF study.



Source: Austin Brown, Transportation Energy Future study

LDV Market penetrations estimates from MA3T in the VTP GPRA FY2012 report

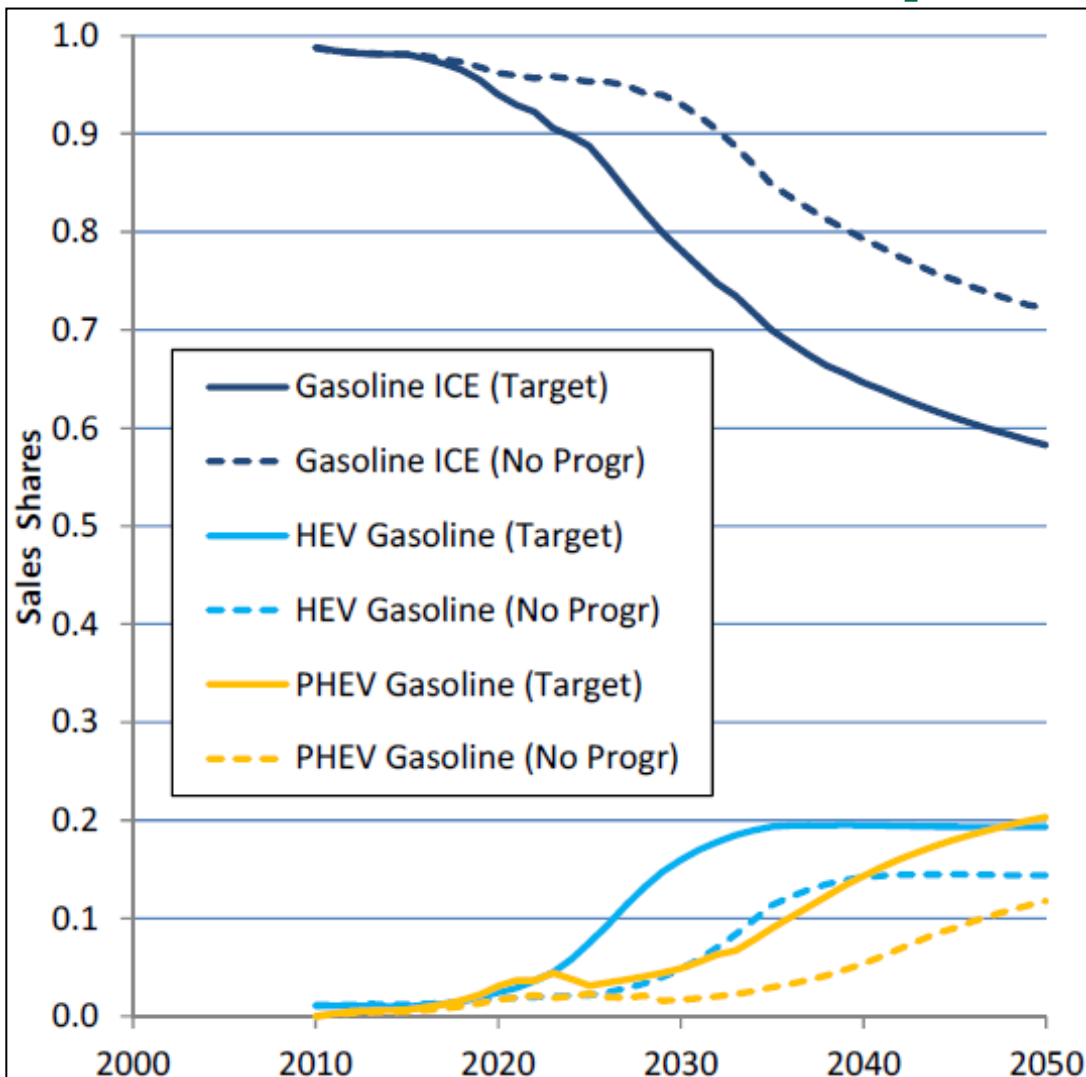


FIGURE 5 LDV Market Penetration Estimates for No Program and Target Cases

Source:
J. Ward, T.S. Stephens, and A.K. Birky.
ANL-12/25.
Vehicle Technologies Program
Government Performance
and Results Act (GPRA) Report
for Fiscal Year 2012.

ORNL Gamma method (a MA3T product) was used by the PHEV Calculator of fueleconomy.gov

In MA3T: 3 drivers by 3 Gamma distributions

My Selections

Vehicle >>

Miles >>

On a typical day, I drive...
30.0 miles

Annual miles...
12,000

Charging >>

My home charger...
☒ 220V ☐ 110V

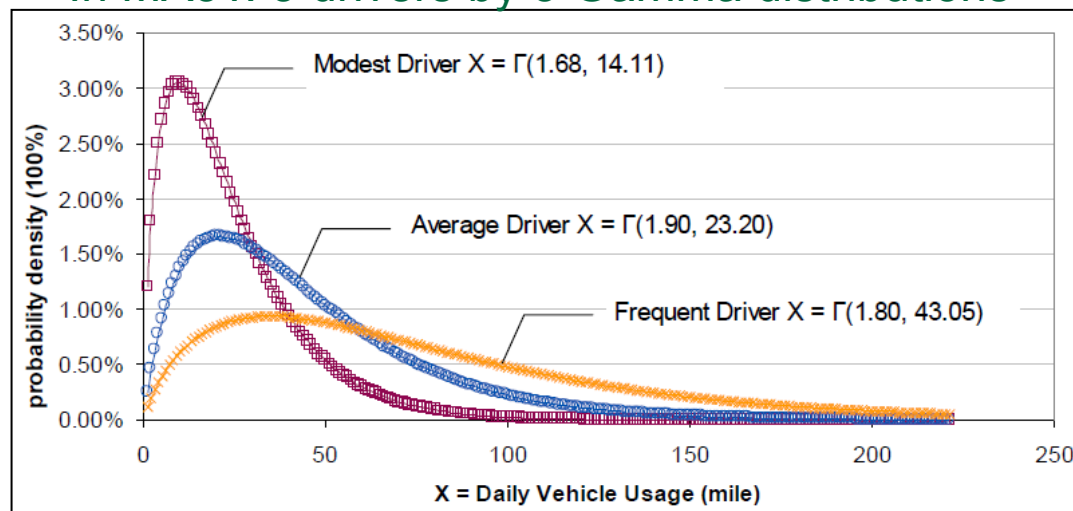
My charger at work...
☒ 220V ☐ 110V ☐ None

Days per week that I will drive to work...
3

Distance to work (one-way)...
10 miles

Prices >>

Recalculate Start Over



Annual ▾

	Gasoline	Electricity	Total
Fuel Costs	\$106	\$477	\$582
Miles	1,097	10,903	12,000
Fuel Used	30 gallons	3,974 kWh	—

Average number of gas station visits per year: about 4.

So far, 5 published and 5 working papers result from the MA3T project.

• Published peer-review articles

- Lin, Z., Dong, J., Liu, C., & Greene, D. (2012). Estimation of Energy Use by PHEVs: Validating Gamma Distribution for Random Daily Driving Distance. *Transportation Research Record*, 2287(1), 37-43.
- Lin, Z. (2012). Optimizing and Diversifying the Electric Range of Plug-in Hybrid Electric Vehicles for U.S. Drivers. *International Journal of Alternative Powertrains*, 1(1), 108-194.
- Dong, J., & Lin, Z. (2012). Within-day recharge of plug-in hybrid electric vehicles: Energy impact of public charging infrastructure. *Transportation Research Part D: Transport and Environment*, 17(5), 405-412.
- Lin, Z., & Greene, D. L. (2011). Promoting the Market for Plug-In Hybrid and Battery Electric Vehicles: Role of Recharge Availability. *Transportation Research Record*, 2252(1), 49-56.
- Lin, Z., & Greene, D. L. (2011). Assessing Energy Impact of PHEVs: Significance of Daily Distance Variation over Time and Among Drivers. *Transportation Research Record*, 2252(1), 99-106.

• Working papers

- Lin, Z.. BEV Range Optimization. Submitted and revising.
- Greene, D.L., Lin, Z, Dong, J. Analyzing the Sensitivity of Hydrogen Vehicle Sales to Consumers' Preferences. Submitted manuscript.
- Lin, Z, Dong, Greene, D.L.. Hydrogen Vehicles: Impacts of DOE Technical Targets on Market Acceptance and Societal Benefits. Submitted manuscript.
- Dong, J., Liu, C., Lin, Z.. Charging Infrastructure Planning for Promoting Battery Electric Vehicle Market: An Activity-Based Assessment Using Multiday Travel Data. Working paper
- Documentation for the Market Acceptance of Advanced Automotive Technologies (MA3T) model. Working paper.

Collaboration with colleagues in the field has made the progress of the MA3T project possible.

- **Working on preparing input data and processing model results with Jonathan Ford and Karen Sikes (SRA International, Inc.)**
- **Working on vehicle attribute data and application of MA3T in analyses with Tom Stephens and Aymeric Rousseau (Argonne National Laboratory)**
- **Working on scenario setup and infrastructure analysis with Jing Dong (Iowa State University)**
- **Worked on electricity carbon intensity with Laura Martin (DOE/EIA)**

We need to better understand consumer behavior, industry behavior, technology innovation, and associated uncertainties.

- **Remainder of FY13**

- Release of the calibrated and validated version
- Submit the 5 working papers for publication, including the documentation

- **FY14**

- Continued routine data updates
- Inform MA3T with new driving and charging data.
- Incorporate recent insights from surveys and behavior theories.
- Enhance MA3T to more explicitly account for uncertainties.
- More work on model validation
- Promote use of the model and learn from users

Summary

- **The goal of MA3T is to provide a useful, user-friendly and credible tool for scenario analysis.**
- **Toward this goal, we made FY13 progress on structuring upgrades, data updates, calibration, validation, application and publication**
- **Great thanks to DOE, collaborators, and users and reviewers**
- **More work needs to be done**